Spin Rate Sensor for Fuzing Applications, Theory and Test Results

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Abstract

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18

Overview

- Theory
  - Magnetic Field Sensor
  - Application
- Test
  - Methodology
  - Hardware
  - Set Up
  - Results
- Conclusions
- What's Next

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Roles

- Army Sponsor
  - **Ultra Sensitive Integrated Magnetic Field Sensors For Fuze Applications, Army Contract Number: DAAE30-99-C-1068**

- TPL, Inc **SBIR Phase II Contactor**-- Sensor
  - Kaman Subcontractor – Data Recorder and Packaging
  - Dayron -- 40 mm projectile, Range, Test

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Spin Rate Sensor Test Team

Dale Spencer , Tim Tiernan ,William Konick, Carlos Tessonniere, Jim Nasternak , Kenny LaClair , Wes Sprouse , Pete Solari
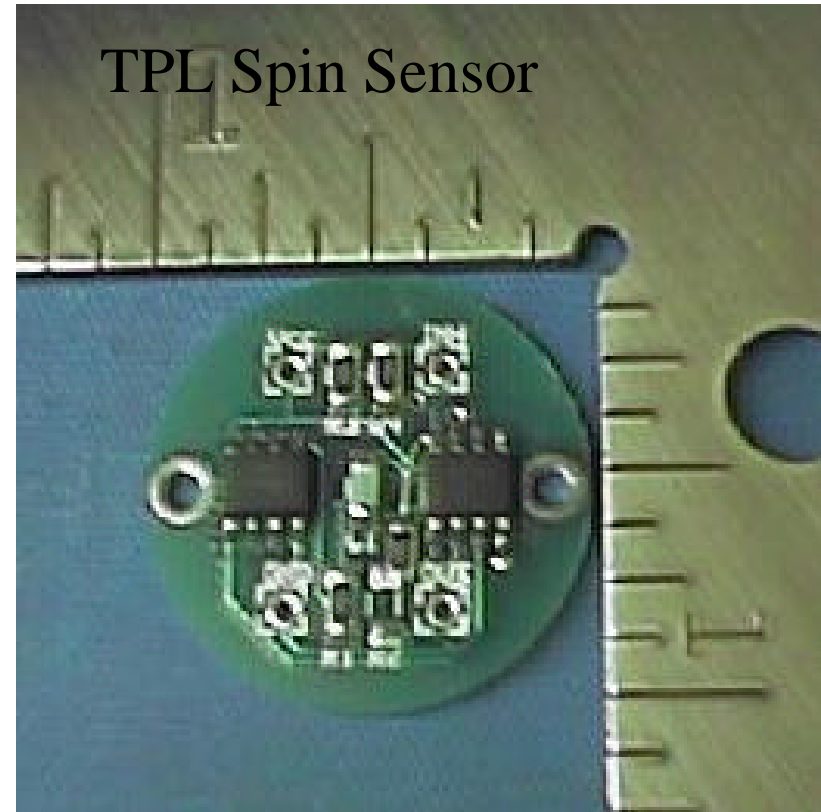
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Theory -- Magnetic Sensor

- Giant Magnetoresistive material.
- The sensor can detect the ambient magnetic field of the earth with a high signal to noise ratio.
- The response of a GMR sensor is strongly related to its orientation with respect to a magnetic field.
- As the munition spins,
  - the sensor mounted inside changes direction with respect to the earth's magnetic field.
  - a sinusoidal waveform is output by the sensor as it moves from alignment to disalignment with the earth's magnetic field with each revolution of the munition.

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Theory Applied

- **Application Theory Developed by TPL, Inc**
  - Resolve shell dynamic rotations
  - Rotations for fixed rifling equal distance
  - Multiply rotations to obtain distance
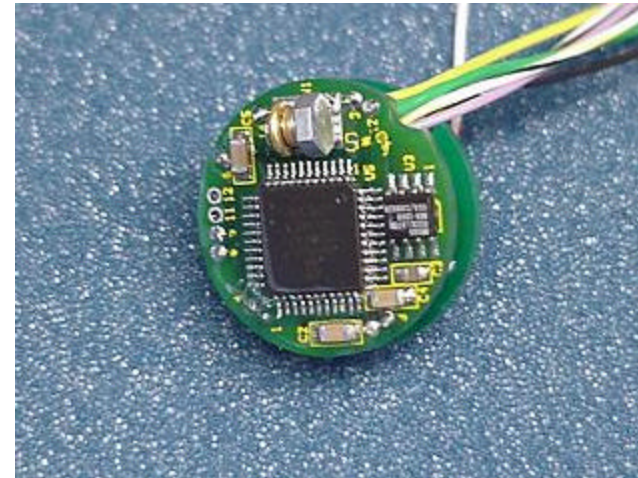

TPL Spin Sensor

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Test Methodology

- **Dynamic Firing Test**
  - Validate Theory through live fire demonstration
  - Build Sensor
  - Integrate Sensor and Data Recorder into projectile.
  - Fire Projectile in Gun with known rifling
  - Measure projectile velocity
  - Compare Projectile turns per second with velocity
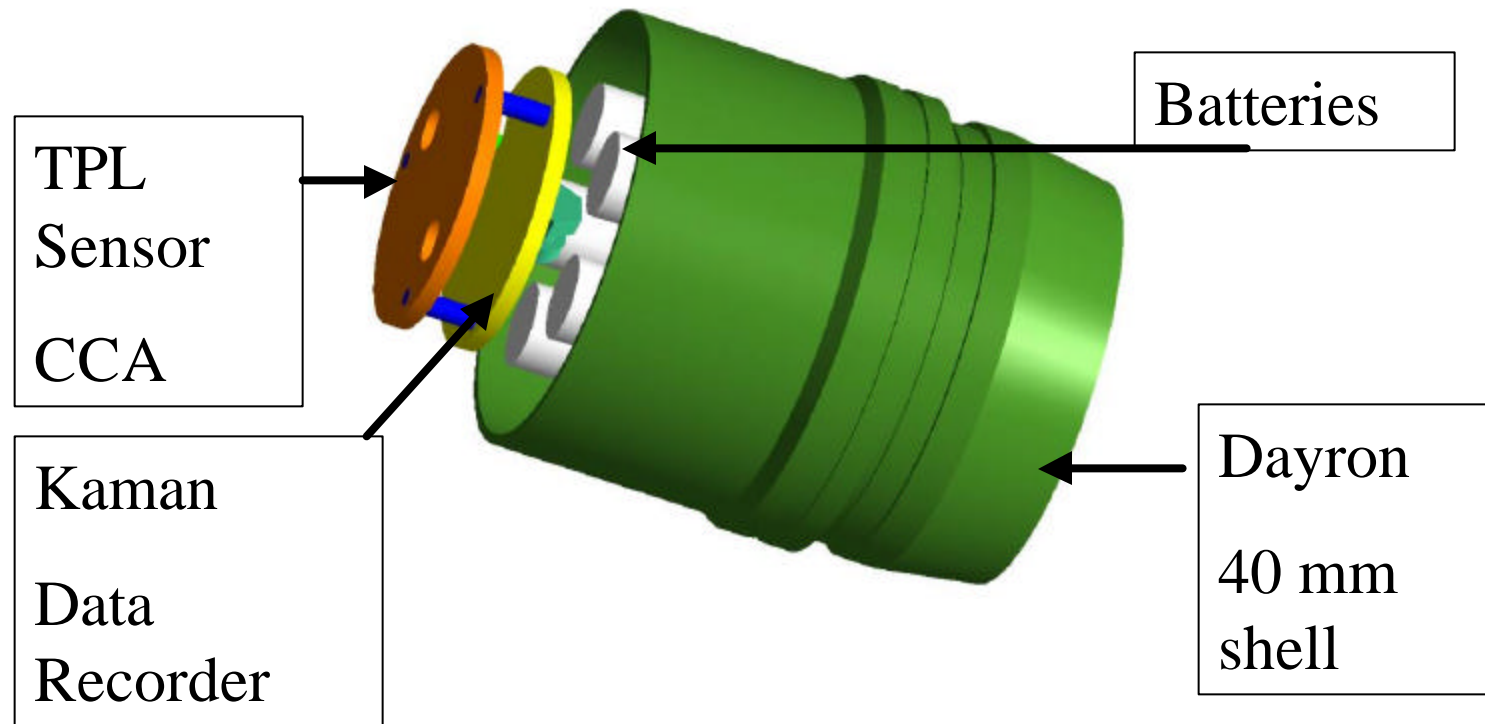

KAMAN Data Recorder

Integrated with TPL Spin Sensor

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Conceptual Package for Test

TPL Sensor CCA

Kaman Data Recorder

Batteries

Dayron 40 mm shell

3-D Packaging by R. Spooner, Kaman
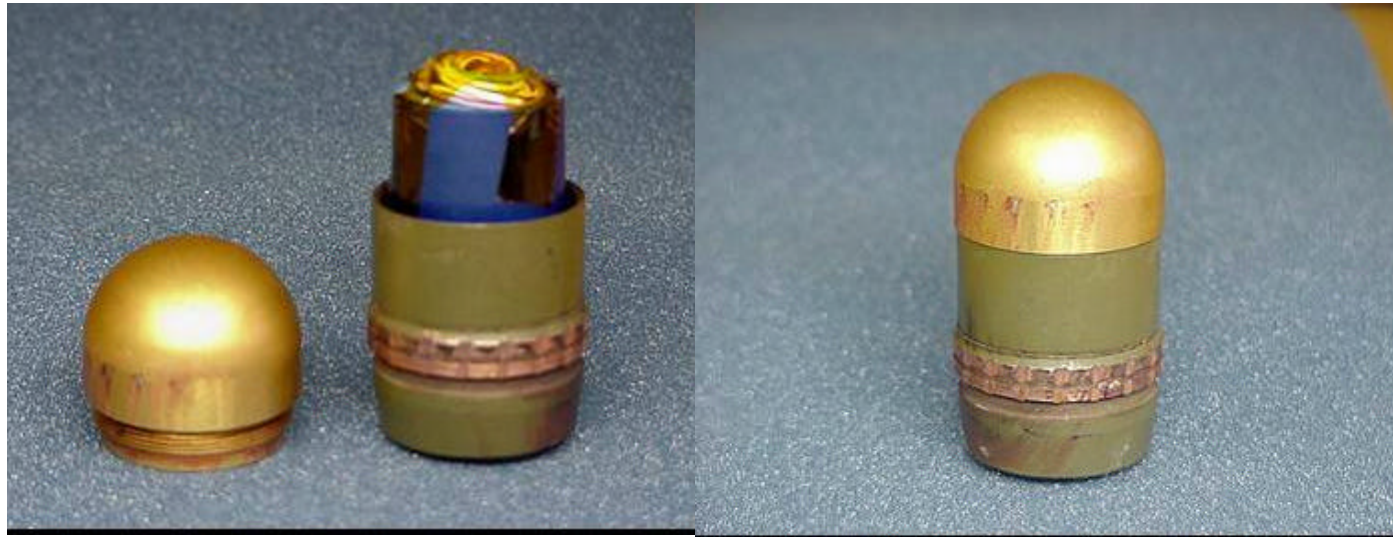
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Note: Rifling Grooves, this projectile has been fired and recovered

Data Interface

Hyperterminal

RS-232 Bus

Serial Bus

RS-232 Converter

Laptop computer

Spin Sensor/ Data
Recorder and Battery
Assy.
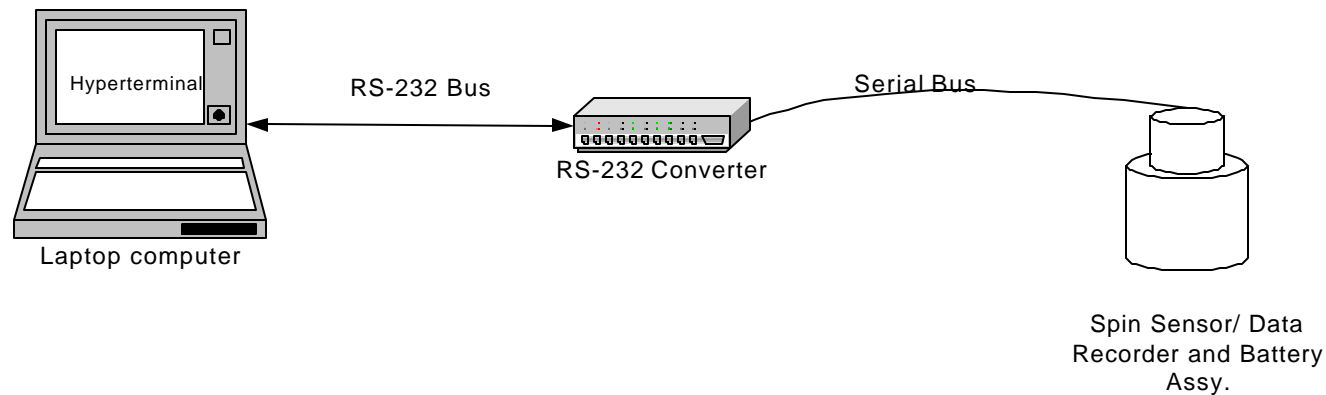
- **PC Running Hyperterminal**

- **Arming Parameters Set Via RS-232 Port**

- **Data Downloadable To PC's Via RS-232 Port**

- **All Code Embedded in Recorder**
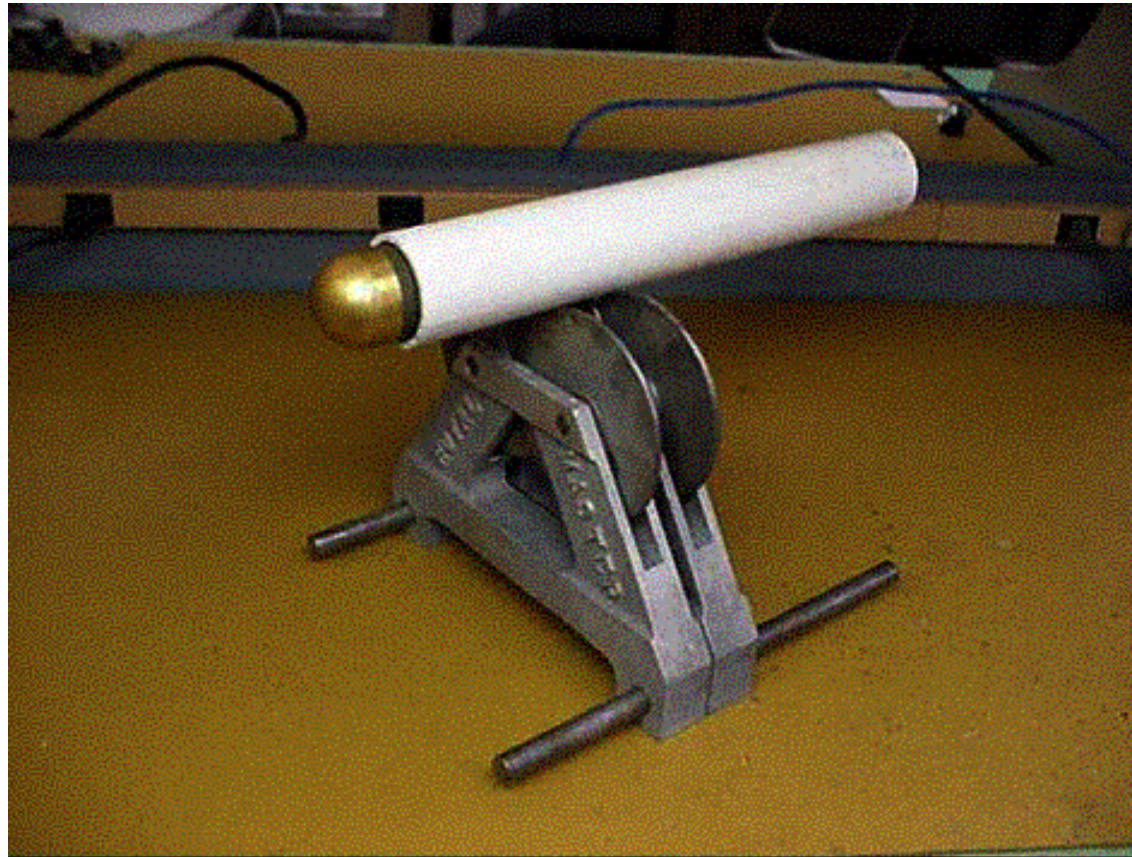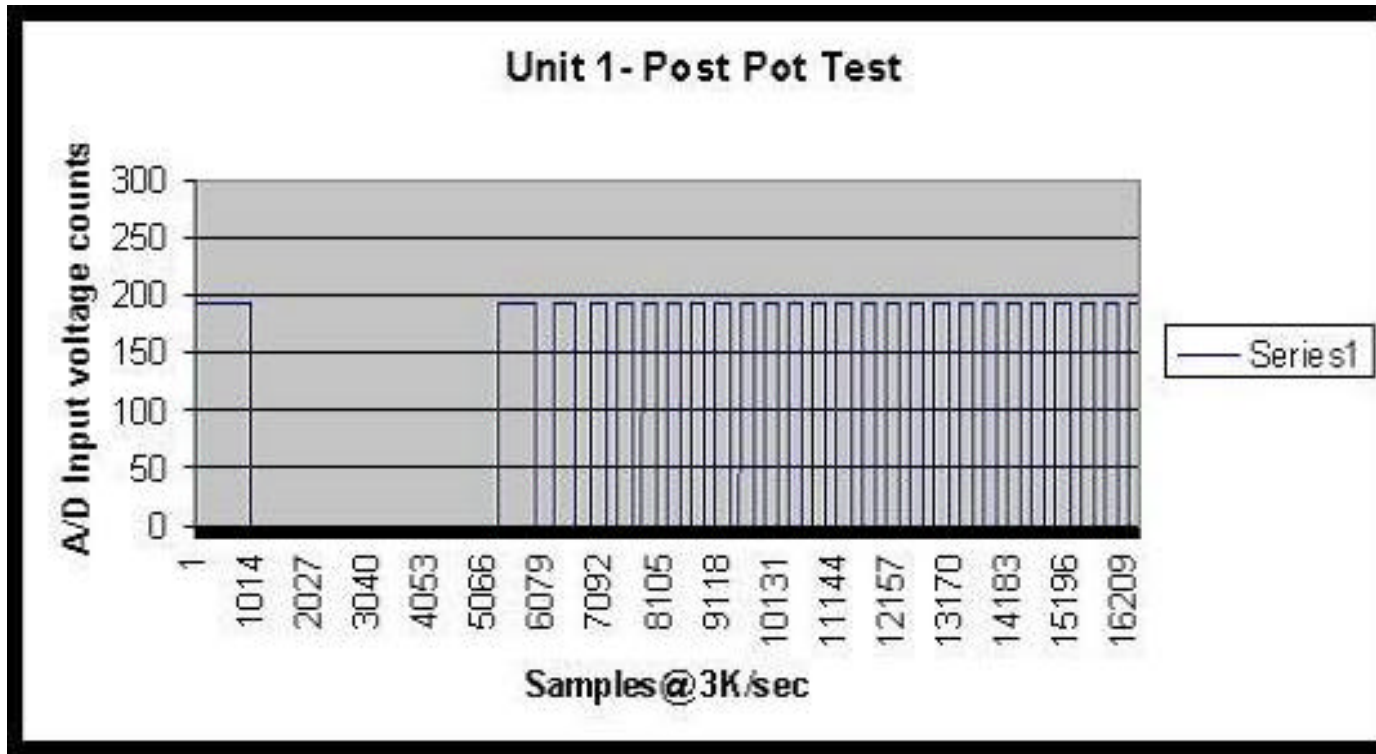
- **No peculiar PC software**

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Bench Test

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Bench Test

Spin up rate as expected

Transition from low to high as expected
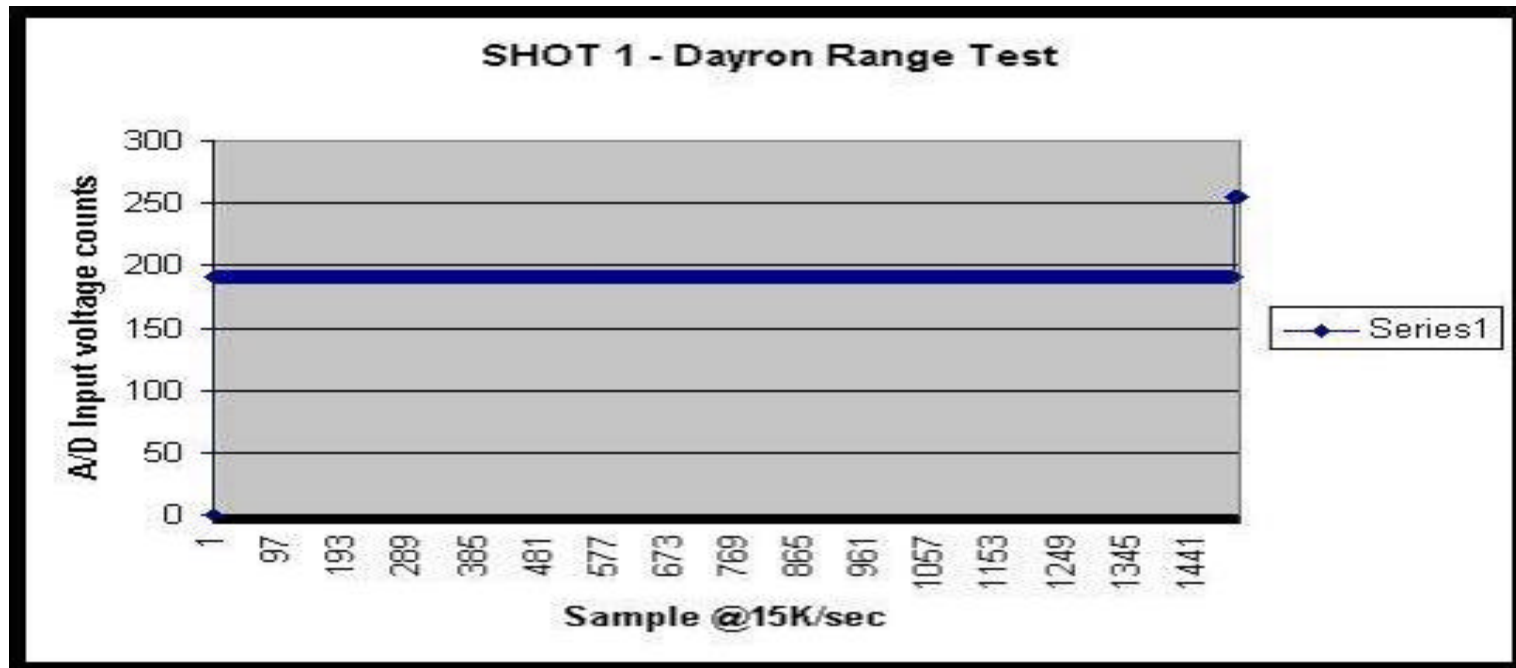
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Test Range

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Shot # 1 Results

- •Flat Line Indicated Problem in First Test

  - •First Bit Low and Last High Indicated Recorder OK

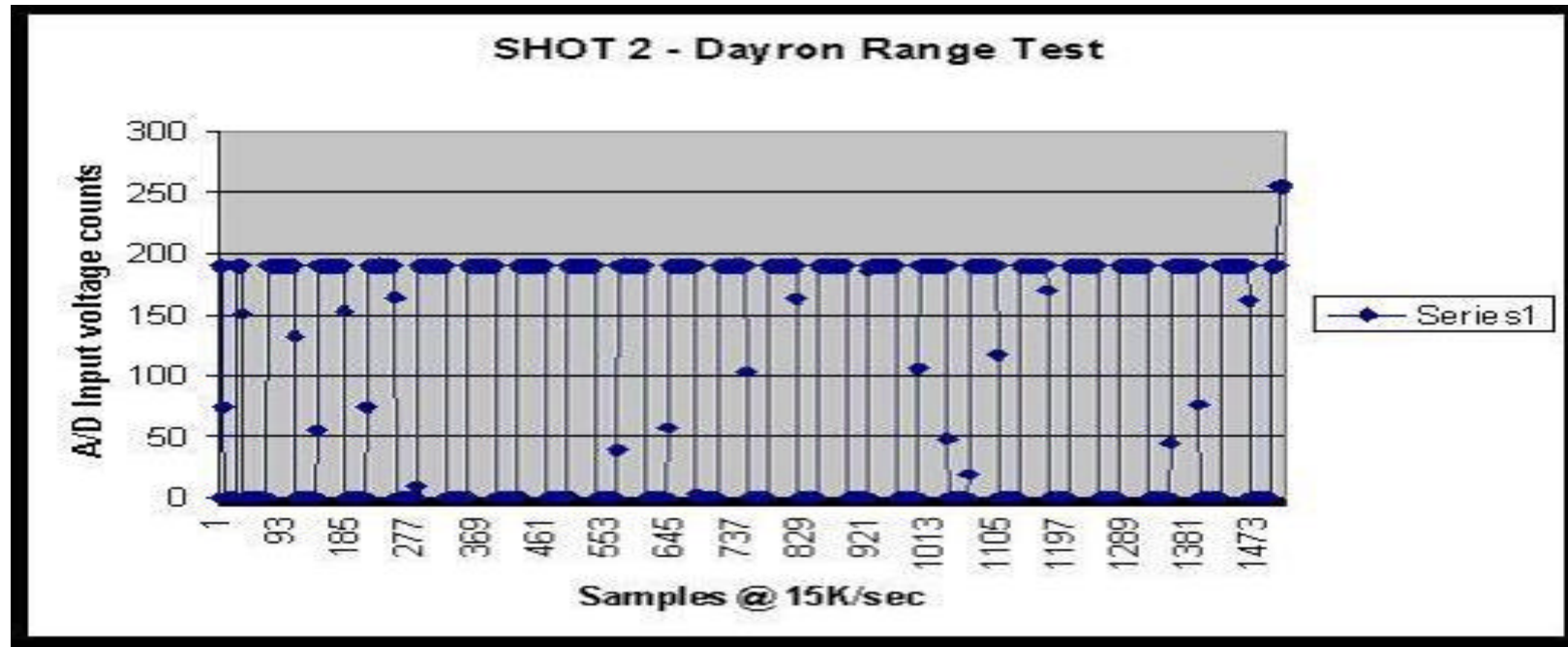 - •Digital Value Corresponded to Saturation

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Shot # 2 Results

- Interesting Data

    •Calculated velocity higher than expected

    •Decide to measure velocity with laser diode velocimeter for next shot
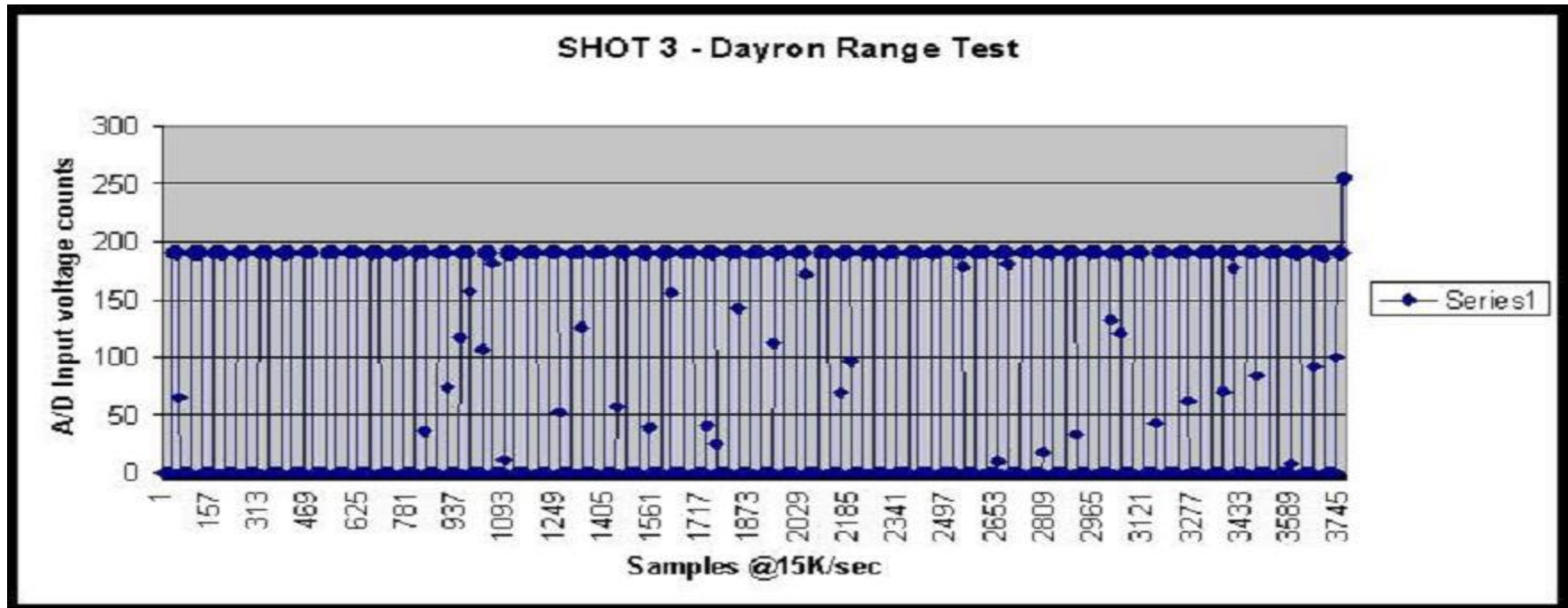
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Test Shot #3

SHOT 3 - Dayron Range Test

- Good Data

- Measured Velocity = Spin Rate Velocity < 1% error

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Test Results

Shot #3	Measured Muzzle Exit Velocity (ft/sec)	Weight (lb)	Number of Turns	Predicted Flight Distance @ 0.25sec Flight Time (ft)	Turns Calculated Flight Distance (ft)	Error (%)
Dayron Round	**813**	**0.740**		203.25		
SR Round	**831**	**0.722**	51.5	207.75	206.00	**0.84**

Predicted Flight Distance == Muzzle Velocity * Flight Time = 831 * 0.25 = 207.75 ft

Turns Calculated Flight Distance = # of Turns * 4 ft/Turn = 51.5* 4 = 206.0 ft

% Error = ((Predicted Flight Distance - Turns Calculated Flight Distance) / Predicted Flight Distance) * 100 = ((207.75 - 206)/207.75) * 100% = 0.84%

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Conclusions

- Test was a success

- Sensor capable of resolving spin rate accurately

- Sensor is survivable and working immediately upon exit from barrel

- Recorder is survivable and working prior to exit from gun barrel

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